Journal of Supply Chain Management Systems
8 (3) 2019, 1-12
http://publishingindia.com/jscms/

Submitted: 22 April, 2019
Revised: 25 May, 2019
Accepted: 31 May, 2019

Factors Affecting Bullwhip Effect: Indian Sectoral Study

Sachin Gupta*, Anurag Saxena**

**Assistant Professor, School of Information Technology, Vivekananda Institute of Professional Studies, New Delhi, India. Email: orsachin@gmail.com; sachin.gupta@vips.edu*

***Professor, School of Management Studies, Indira Gandhi National Open University, Maidan Garhi, New Delhi, India. Email: anurags@ignou.ac.in*

Abstract

Amplification of demand, as we move up (from customer to supplier) in a supply chain, is considered as the bullwhip effect. It causes inefficiencies in the supply chain as the entire supply chain gets disturbed due to demand amplification. It results in either overproduction or shortage at each echelon present in the supply chain. Huge amount of research is available to mitigate the bullwhip effect in supply chain management. The reasons for the occurrence of bullwhip effect vary from sector to sector. Bullwhip effect has already been explored within the organisation as well as between the organisations. The present study examines the various factors that cause a bullwhip effect in 10 different Indian sectors. It has been found that the bullwhip effect varies from sector to sector, and the factors that are causing bullwhip effect also vary from sector to sector with a differently explained variability. Further, factor analysis is performed on selected sectors to see how these factors vary among the companies that are having bullwhip effect from those which are not having the bullwhip effect.

Keywords: Bullwhip Effect, Mitigation of Bullwhip Effect, Factor Affecting Bullwhip Effect, Supply Chain Management

Introduction

Every organisation wants to streamline its operations to satisfy the needs and wants of the customer in a better way than the competitors present in market (Christopher, 1992; Macbeth and Ferguson, 1992). Over the last three decades, this streamlining of operations with their production and logistics is considered as supply chain management. In present technological world, the globalisation is playing its part to satisfy the needs of customer and satisfaction level in an optimal manner; hence, the competition is not lying within the local players but with the entire outside world dealing with that product or service. Due to this competition, it is an utmost requirement that companies should minimise their production; operations and logistics cost; enhance the quality up to global standard and provide a valuable product to the customer in order to gain market share (Lee & Billington, 1992; Lamming, 1996). Shorter life cycle of a product, changes in technology, cut-throat competition and globalisation force the organisation for the implementation of its supply chain. The supply chain consists of the number of entities like supplier, manufacturer, wholesaler and retailers to work in a chain to satisfy the demand of customer (New & Payne, 1995). The supply chain can be understood in terms of the flow of information, money, ownership of the product, etc. The information and money are moving upstream from customer to supplier, and the ownership is moving from supplier to customer. Managing the supply chain includes carrying out the various functions such as procurement of raw material, manufacturing to convert raw material into finished goods (with the help of resources like machine, men, etc.), inventory management until it is delivered to customer, logistics (mode of delivery and packaging), finance (dealing with money to carry out operations), marketing (selling and branding), information system, etc.

The amplification of demand as we move up in upstream from customer to supplier is considered as bullwhip effect (Lee et al., 1997). This distortion hampers the functioning of the supply chain in an amplified manner. It results in either overproduction or underproduction, shortage of cash-in-hand to carry out operations, stock-out or extensive inventory carrying the cost, the dissatisfaction of customer and significantly decreases the profit (Metters, 1997). The plethora of research is available to identify the causes of the bullwhip effect. Behavioural as well as operational issues cause the bullwhip effect. Forrester (1961) carried out the seminal study regarding the behavioural issue that deals

with the dynamism present in the supply chain causing demand amplification. Delay in decision, information and feedback result in an unstable operation that causes the bullwhip effect. Sterman (1989) conducted the simulation famously known as beer distribution game to verify the amplification in the supply chain in the upstream direction. Besides these behavioural aspects, Lee et al. (1997) identified four main reasons that cause bullwhip effect which is termed as demand signal forecasting, rationing and shortages, price fluctuation and order batching. The study gave this amplification phenomenon the nomenclature of the bullwhip effect. Simultaneously, Jones & Towill (1997) termed this phenomenon as Forrester effect. The popularly known phenomenon of the bullwhip effect is also known as the whipsaw effect or whiplash effect. Various industries like electronic, automobile, telecom, IT, FMCG, etc. have already been explored to see the presence of the bullwhip effect. Presently, studies on specific industry dealing with bullwhip effect are also available.

The present study explored the operational causes of the bullwhip effect present in various Indian industries. The study also considered the collective impact of variables that cause the bullwhip effect in various Indian sectors. Most significant factor (factor that explains most variability) frequency corresponding to each variable is identified to know the importance of variables that cause bullwhip effect.

Literature Review

Forrester (1961) studied the industrial dynamics using simulator DYNAMO to show that the amplification of demand increases as we move up in the supply chain. Later, Sterman (1989) used a BEER distribution game to implement it in a better and exhaustive way. Both used simulator as a part of the behavioral aspect of the bullwhip effect. The operational aspect of bullwhip effect was studied using mathematical model and various industries which were experiencing demand amplification illustrated in the study and termed this amplification phenomenon as bullwhip effect (Lee et al., 1997). All three studies played a seminal role to define and establish the phenomenon of amplification of demand as the bullwhip effect. Some of the nomenclatures used by Lee et al. (1997) are discussed in a plethora of studies. Rationing and gaming is termed as Houlihan effect (Houlihan, 1987). Order batching is termed as Burbidge effect which was coined in 1991 (Burbidge, 1991) and demand signal processing and non-zero lead times is known as Forrester effect (Forrester, 1961). Besides these effects, many other theories described ways that either result in bullwhip effect or enhance it. Information flow, lead-time, promotional effect, inventory management, marketing, number of echelons, material delay, etc. causes a bullwhip effect. Paik & Bagchi (2007) described some of the aforementioned factors. Geary et al. (2006) gave ten principles to reduce the bullwhip effect out of which four were earlier published (Lee et al., 1997).

Cannella et al. (2013) developed various metrics for bullwhip effect and supply chain performance is calculated using simulated data. In another study the financial data is studied to seek the performance of the firm and its relationship with bullwhip effect (Mackelprang & Malhotra, 2015). A case study on Brazil automobile sector was carried out to seek the green existence of green bullwhip effect in the industry (Seles et al., 2016). Ravichandran (2006) carried out two case studies in Indian scenario to manage the bullwhip effect. Enterprise resource planning and vendor managed inventory were used as effective tools to counter the bullwhip effect. Greek retail companies were studied (Kelepouris et al., 2008) on the basis of secondary data and it was found that the information sharing reduces bullwhip effect and increase in lead time increases the bullwhip effect, whereas Duc et al. (2008) illustrate that bullwhip effect does not necessarily increase with increase of lead time. A study on retail sector pricing strategy concluded that when the demand is serially correlated everyday low pricing results in a decrease of the bullwhip effect and increase in profitability (Hamister & Suresh, 2008). It was suggested that the augmented collaborative planning, forecasting and replenishment model is better than CPFR model because it also contained information like demand fluctuation and replenishment besides the point of sales information for the retail industry (Chang et al., 2007).

Forecast accuracy may result in a decrease of the bullwhip effect, but in order-up-to policy, the bullwhip effect always exists (Chiang et al., 2016). The study also concluded that the aggregate forecasting results in the decrease of the bullwhip effect, but in the US auto industry, it does not. Bullwhip effect across the US on various sectors like manufacturing, wholesale, mining, retail, etc. was computed (Isaksson & Seifert, 2016) and significant bullwhip effect has been found among them, and bullwhip ratio was used to conclude the result. A study on US data concluded that only wholesale industry is having a bullwhip effect whereas retailers and manufacturing industry do not possess this effect (Cachon et al., 2007). Monthly data of various US industries is explored and intra-industry bullwhips for the cases of manufacturing, shipping and orders are analysed (Jin et

al., 2017). In the oil sector, economics and administrative work play an important role in case if supply flow does not depend on customer demand to avoid the reverse bullwhip effect (Hull, 2005).

In a primary data-based study, European electronic industry has been explored (Kaipia, Korhonen, & Hartiala, 2006) where bullwhip effect is explored using planning nervousness which is a function of varying and lack of planning process, multi-decision making phases, long planning horizons and delay in information flow. The food supply chain is studied which measured the bullwhip effect at the outlet level, product level and echelon level (Fransoo & Wouters, 2000). Telecom sector has also experienced a bullwhip effect. Simulation on capacity planning, stock and information system has been performed and it is found that the increase in these variable results in a decrease of bullwhip effect (Mahmoudi & Lamothe, 2006). The present study explores 10 different sectors on 19 operations and financial variables based on secondary observations collected from Prowess.

Research Methodology

The objective of the study is to identify the factors affecting the bullwhip effect that is varying from sector to sector. To fulfil this objective, 19 financial and operational variables that affect company performance are analysed under study (defined in Table 1). The literature available on supply chain performance is varying between the two parts, one is the financial performance, and the other is the nonfinancial performance (Chen & Paulraj, 2004). The present study uses the heterogeneous financial variables under the constructs of profitability (financial performance), inventory replenishment (cycle length and turnover), marketing expenses (direct and indirect), size (total assets) and supply chain drivers (transportation and communication infrastructure) to explain the bullwhip effect in the supply chain. The literature available to select these variables is as follows:

Bullwhip Ratio

Bullwhip ratio is computed on the basis of the cost of production and price of goods sold. Chen et al. (2000) develop the measurement of a bullwhip on the basis of demand and inventory ratio famously known as order variance ratio. In another study, Disney & Towill (2002) measured the demand amplification on the basis of inventory variance ratio. Cagnazzo et al. (2010) emphasised that the metric should be on basis of internal efficiency as well as effect to customers also. The present study uses the ratio of the coefficient of variation of cost of production to the cost of goods sold. Fransoo & Wooter (2000) also use the ratio of the coefficient of variance. The ratio of the coefficient of variation of cost of goods sold to the coefficient of variation of the cost of production is computed for every sector, and this ratio is used as measure of bullwhip effect. If the ratio is more than one then it implies the presence of bullwhip effect at the manufacturer end and if the ratio is less than one then it implies as the situation of no bullwhip effect.

Profitability

The impact of the bullwhip effect on the performance of the company has been studied in many studies. Presence of bullwhip effect decreases the profitability (Dominguez et al., 2015). Inventory carrying cost along with total cost also increase due to the presence of the bullwhip effect (Li, 2013). Vickery et al. (2003) used the return on investment and profit before tax as a construct to measure the performance of the supply chain. Green et al. (2008) also used return on investment and profit margin on sales. The present study takes profit after tax, return on capital employed and current ratio to see the performance of the company under the bullwhip effect.

Inventory

Bullwhip effect increases the variability in inventory levels. The number of day's inventory outstanding is causing bullwhip effect and hence to reduce bullwhip effect reduction in inventory outstanding is suggested by Tsai (2008). Increase in the inventory variability leads to the disturbance in the cash conversion cycle of the entire supply chain and hence causing more bullwhip effect (Tangsucheeva & Prabhu, 2013). Inventory replenishment does play a role to counter the bullwhip effect. Higher the replenishment rate signifies the less number of inventory outstanding period, and hence less is the bullwhip effect (West, 1986). In the present study, the replenishment period of finished goods inventory and the raw material is studied. Raw material cycle, WIP cycle and finished goods cycle have been studied to see the impact of these on bullwhip effect. These variables are used as proxy variables that signify the replenishment. Simultaneously the turnover time of raw material, WIP and finished good is also studied.

Operational Efficiency

Dealing with situations like no demand, a lump in demand and unexpected demand with the estimated demand show

the efficiency of the system. Akyuz & Erkan (2010) review supply chain performance with its operational efficiency. It emphasises on a metric that measures the operational efficiency of the supply chain. Change in stock for finished goods and change in stock of WIP are considered as operational efficiency parameter in the present study. Lower is the value of change in stock of both the variables higher the efficiency that mitigates the bullwhip effect.

Marketings

Marketing is considered a tool to reduce inventory held as any of supply chain entity. Sales promotion, trade credit and discount are important aspects of marketing in which sales promotion is non-direct nature and trade credit and discount are of direct nature. Sometimes marketing is used as a tool to increase the sales of the product and movement in warehouses. Marketing expenses to are causing a bullwhip effect. If the elimination of price promotion is removed in the functional product than the efficiency of the supply chain can be increased (Fisher, 1997). Lee et al. (1997) identified the promotion effect as one of the four main reasons due to which the bullwhip effect occurs. Promotion effect increases the variability in sales that causing inventory-related problem, the promotion policy increases the current sales because of price-sensitive demand but decreases the future sales, as a result stockpiles at the various entities of supply chain causing the disturbance in entire supply chain (Mela et al., 1998; Neslin, 1990; Lummus et al., 2003).

Size

The size of the company also affects the bullwhip effect. As the size of the company increases, the complexity to deal with supply chain also increases. The delay in information processed become complex, and relationship building among the supply chain entities becomes complex in nature. Cachon et al. (2007) found a significant positive relationship of size with the amplification of demand. The present study also takes size as a variable to explain that the amplification exists in demand.

Supply Chain Drivers

Transport infrastructure and communication infrastructure are taken as supply chain drivers in the present study to analyse the impact of these to reduce the amplification of demand. Communication infrastructure plays an important role in the effective implementation of the information system among supply chain entities. Lee et al. (1997) identified that information system plays a major role in diminishing of bullwhip effect as order replenishment must be done based on end-user, not based on the downstream supply chain. Information system not only plays a role in replenishment, but it plays a role in planning and controlling process as well as in forecasting. Logistics management is a vital aspect of supply chain management. The only companies that recognise the vital role of logistics in supply chain management can achieve competitive advantages (Christopher, 1994). The factors, their proxy variables with a definition can be read from Table 1.

Table 1: Variables Taken Under the Study

S. No.	Factors	Proxy Variable	Explanation of Variable
1	Production	Cost of production	This data item denotes the manufacturing cost of finished goods produced during an accounting period.
2	Sales	Cost of goods sold	The cost of goods sold is the cost directly associated with the production of the goods sold during the accounting period.
3	Marketing expenses	Rebates & discount expenses	Marketing mechanism in which invoice is reduced at the customer end.
		Sales promotion expenses	It involves all the expenses that promote sales apart from the advertisement. These expenses include after-sales service, the incentive to dealer or seller, brokerage and commissions, direct contacted business promotion expenses, public relation, etc.
		Advertising expenses	Money spent by the company to promote its product. It is non-direct in nature.
4	Performance of the company	Profit after tax	Net profit of the company after tax.
		Return on capital employed	It is a ratio of the percentage of net profit with the total asset employed by a company.
		Current ratio (times)	It is the ratio of current assets to the current liabilities.
5	Operational efficiency	Change in the stock of finished goods	Difference between the value of the closing stock of finished goods to the value of the opening stock of finished goods.
		Change in the stock of WIP and semi-finished goods	Difference between the closing stock of work in progress to the opening stock of work in progress goods.

S. No.	Factors	Proxy Variable	Explanation of Variable
6	Replenish-ment	Raw material cycle (days)	It represents the number of days during which the stock remains in the companies warehouse before introduced to the production process.
		WIP cycle (days)	It represents the number of days during which the stock remains in the production process before converted into finished goods.
		Finished goods cycle (days)	It represents the number of days during which the product remains in the companies warehouse before it is sold to the customer and dispatched.
		Raw material turnover (times)	It denotes the number of times raw material is introduced in the production process in one financial year.
		WIP turnover (times)	It denotes the number of times WIP is converted into finished goods in one financial year.
		Finished goods turnover (times)	The number of times stock of finished goods is converted into sales in one financial year.
7	Size of the organisation	Size	The total asset of the company as on the last day of the financial year.
8	SCM drivers	Transport infrastructure, net	The total value of transport infrastructure owned by the company in that financial period.
		Communication equipment, net	The total value of communication equipment owned or leased by the company in that financial year.

After the identification of variables, 10 sectors are identified to study the factors affecting the bullwhip effect in these sectors. The selected 10 sectors are playing a major role in the Indian economy. Automobiles, Consumer durable, Energy, FMCG (fast-moving consumer goods), IT (information technology), Oil & Gas, Power, Real, Telecom and Utility are the 10 selected sectors. BSE sectoral data is taken from these 10 sectors. The most affected sector from bullwhip effect is consumer durable in which 70% of companies are having more variability in goods sold rather than the variability in production, and real sector is least effected with the ratio of 20%. Rest of sectors is lying in between. The steps involved in research methodology to achieve objectives are shown in Fig. 1.

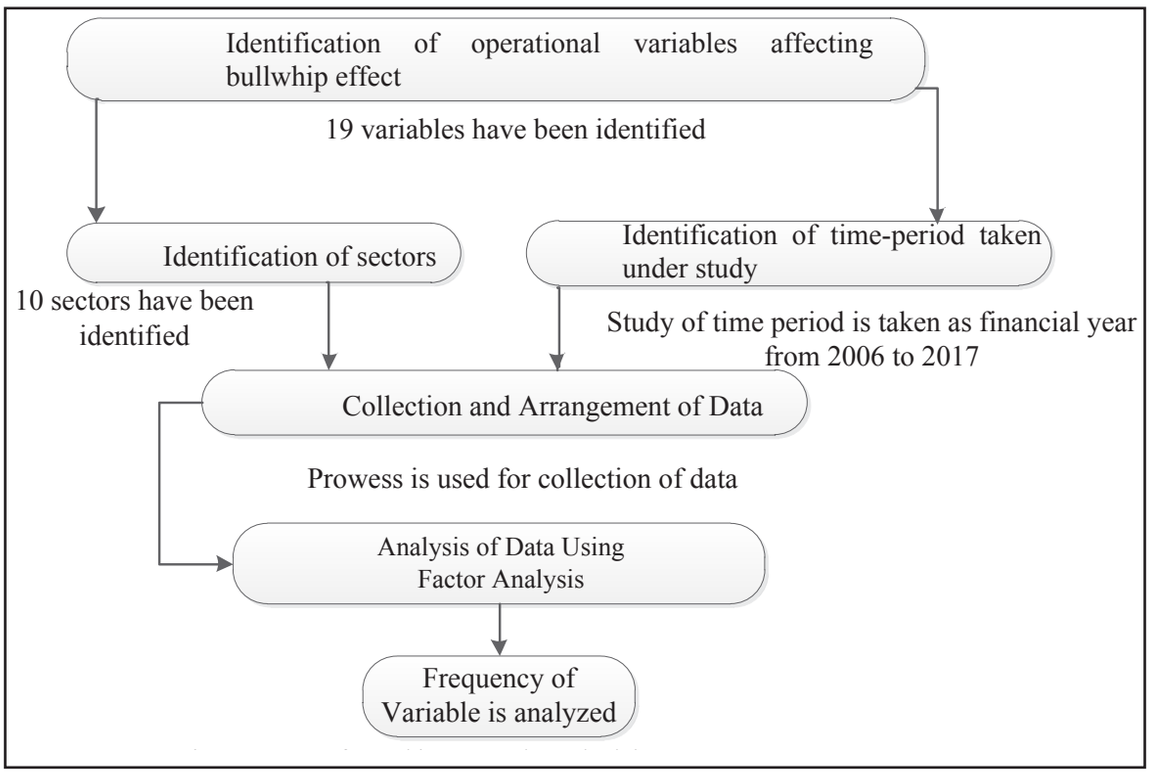

Fig. 1: Steps Performed in Research Methodology

BSE sectoral indices broadly represent the Indian market. Every company present in these sectors in BSE sectoral indices is studied by yearly observations and data is collected from the financial year 2006 to year 2017 using the Prowess database on 19 identified financial and operational variables.

Table 2: Number of Companies Present in Selected 10 Sectors

Name of Sector	Automobile	Consumer Durable	Energy	FMCG	IT	Oil & Gas	Power	Real	Telecom	Utility
Number of Companies	14	10	26	77	57	10	19	10	16	32

Different sectors have a different number of companies. Automobile sector consists of 14 companies in BSE sectoral data. FMCG sector is having the most amount of companies 77 whereas power, real and consumer durable are having 10 companies each. Table 2 represents the various companies present in different sectors.

Data is arranged in chronological order and factor analysis is performed on each sector. The major component of each factor is studied because it explains more variability than the rest of components. Later on, based on the variable present in the major component of factor analysis, a frequency distribution of the variable is formed to check the importance of each variable in the bullwhip effect.

Results and Discussion

Factor analysis is performed on each sector by conducting the following steps using SPSS software version 20. Kaiser-Meyer-Olkin (KMO) test and bartlett's test of sphericity is performed to check the sampling adequacy for each variable as well as the entire model, and this test gives the result about the applicability of factor analysis on given data. The results of chi-square value with the p-value are summarised in Table 3. Any amount less than 0.05 suggests that factor analysis can be performed. After verification of applicability, the principal component analysis method is chosen with Promax rotation. The results obtained from each sector are summarised in Table 3.

Table 3: Major Components of Each Sector with KMO Significance and Explained Variability

Sector	Bartlett's Chi-Square (Significance)	Variability Explained by Major Component	Variables in Major Components	Total Variance Explained
Automobile	214.223 (.000)	44.635	Advertising Expenses (0.858) Raw material cycle (–0.857) WIP Cycle (–0.733) Finished goods cycle (–0.759) Raw material turnover (0.88) WIP turnover (0.978) Finished goods turnover (0.751) Return on capital employed (0.698)	78.679
Consumer durable	61.991 (0.005)	34.293	WIP turnover (times)(0.908) Return on capital employed (0.961) Current ratio (times)(0.599)	84.941
Energy	753.741 (.000)	32.011	Cost of production - work in progress (0.904) Cost of goods sold (0.976) Sales promotion expenses (0.954) Change in stock of finished goods (0.972) Change in stock of WIP and semi finished goods (0.962) Size (0.862)	82.665

Sector	Bartlett's Chi-Square (Significance)	Variability Explained by Major Component	Variables in Major Components	Total Variance Explained
FMCG	1069.541 (0.000)	23.158	Advertising expenses (0.806) Profit after tax (0.820) Size (0.926)	69.948
IT	1336.296 (0.000)	36.491	Sales promotion expenses (0.586) Profit after tax (0.999) Size (0.900) WIP turnover (times)(0.552) Finished goods turnover (times) (0.893)	78.424
Oil and gas	74.901 (0.000)	54.368	Change in stock of WIP and semi finished goods (0.857) WIP cycle (days)(0.909) Transport infrastructure (0.888) Return on capital employed (–0.787)	82.733
Power	143.75 (0.000)	32.967	Change in stock of WIP and Semi-finished goods (0.967) Transport infrastructure (0.911) Profit after tax (0.529)	84.506
Real	60.372 (0.049)	41.740	Sales promotion expenses (0.825) Advertising expenses (0.951) Profit after tax (0.786)	82.228
Utility	823.285 (0.000)	28.426	Rebates & discount expenses (0.999) Cost of goods sold (0.828) Profit after tax (0.922) Size (0.910)	87.396
Telecom	285.502 (0.000)	27.774	Raw material cycle (days)(0.933) Finished goods cycle (days)(0.925) WIP turnover (times)(0.747)	79.368

Some of the prominent observations from Table 3 are as follows. It has been found that different sectors have different variability explained. The utility sector has most variability explained with 87.228% whereas FMCG sector has the least variability explained with 69.948%. The financial and operational variables present only in the first component have been studied (major component). Advertisement expenses with the raw material, WIP and finished goods turnover with return on capital employed presently in major component of automobile sector with positive coefficients whereas raw material, WIP and finished goods cycle are present at a negative level. The results show that advertisement does play a role in the automobile sector in causing of the bullwhip effect. Advertisement expenses and promotion playing a role in FMCG and IT sector, respectively. WIP turnover, return on capital employed and current ratio are affecting durable consumer sector. Transport infrastructure with the change in the stock of semi-finished goods matters in the power sector. Size of the companies matters in the utility sector with rebate and discount expenses. To get more insight about the variables affecting the different sectors frequency distribution of variables is formed, which also suggests the ranking in which these variables are affecting the bullwhip effect is given in Table 4.

Table 4: Frequency of Variables Affecting the Bullwhip Effect in Different Sectors

S. No.	Variable	Name of Sectors	Frequency
1	Profit after tax	FMCG, IT, Power, Real, Utility	5
2	Size	Energy, FMCG, IT, Utility	4
3	WIP turnover (times)	Automobile, Consumer durable, IT, telecom	4
4	Sales promotion expenses	Energy, IT, Real	3

S. No.	Variable	Name of Sectors	Frequency
5	Advertising expenses	Automobile, FMCG, Real	3
6	Change in stock of wip and semi-finished goods	Energy, Oil and Gas, Power	3
7	Return on capital employed	Automobile, Consumer durable, Oil and gas	3
8	Cost of goods sold	Energy, Utility	2
9	Transport infrastructure, net	Oil and gas, Power	2
10	Cost of Production	Energy	1
11	Rebates & discount expenses	Utility	1
12	Change in stock of finished goods	Energy	1
13	Raw material cycle (days)	Telecom	1
14	WIP cycle (days)	Oil and gas	1
15	Finished goods cycle (days)	Telecom	1
16	Current ratio (times)	Consumer Durable	1
17	Raw material turnover (times)	Automobile	1
18	Finished goods turnover (times)	IT	1
19	Communication equipment, net	Nil	0

Surprisingly out of 19 variables, only one variable communication equipment that denotes the net expenses on communication infrastructure is not explaining variability in any of the sectors in major component of factor analysis.

Once the factors affecting bullwhip effect are identified next objective to seek the difference in factors within the sector in the presence and absence of bullwhip effect. Five major sectors among the selected ten sectors are identified. These sectors are Automobile, Energy, FMCG, IT and Utility. A binary variable is declared which is taking the value of one and zero in case the company is experiencing and not experiencing the bullwhip effect, respectively. If the ratio of coefficient of variation of cost of production to the cost of goods sold is more than one then variable is assigned value one otherwise zero. Within the sectors, companies that are experiencing the bullwhip effect are selected and factor analysis is performed and then within the same sector companies that are not experiencing the bullwhip effect are selected and then factor analysis is performed again. The results of five identified sectors are given in Table 5.

Table 5: Comparison Between Factor in Absence and Presence of Bullwhip Effect

Sector	Bartlett's Chi-Square (Significance)	Variability Explained by Major Component	Variables in Major Components	Total Variance Explained
Automobile	18.47 (.005) (Absence of BWE)	80.105	Current Ratio (times)(-0.804) WIP turnover (times) (0.939) Return on capital employed (0.870)	80.105
	45.205 (0.21) (Presence of BWE)	40.817	Advertisement Expenses (0.772) Raw Material cycle (days)(-.960) Raw material turnover (times) (0.945)	85.406
Energy	135.24 (.000) (Absence of BWE)	25.25	Sales promotion expenses (0.896) Change in stock of WIP and semi finished goods (0.999) WIP cycle (days) (0.749)	79.63
	32.6 (.051) (Presence of BWE)	35.031	Advertisement Expenses (0.609) Finished goods cycle (days)(0.896) Raw material turnover (times)(-0.659) Return on capital employed (0.849)	83.286

Sector	Bartlett's Chi-Square (Significance)	Variability Explained by Major Component	Variables in Major Components	Total Variance Explained
FMCG	846.811 (0.000) (Absence of BWE)	26.56	Advertising expenses (0.978) Profit after tax (0.954) Size (0.954) Return on capital employed (0.513)	78.18
	691.771 (0.000) (Presence of BWE)	27.93	Sales Promotion(0.549) Change of stock of finished goods (0.766) Profit after tax (0.754)	79.4
IT	1515.897 (0.000) (Absence of BWE)	40.274	Sales promotion expenses (0.824) Profit after tax (0.905) Size (0.963) WIP turnover (times) (0.893) Finished goods turnover (times) (0.511)	88.607
	253.812 (0.000) (Presence of BWE)	33.514	Sales Promotion expenses (0.971) Profit after tax (0.976) Size (0.984)	77.938
Utility	883.014 (0.000) (Absence of BWE)	29.671	Rebates & discount expenses (0.999) Advertising expenses (0.748) Cost of goods sold (0.998) Profit after tax (0.949) Size (0.901) Finished goods turnover (0.712)	87.396
	648.461 (0.000) (Presence of BWE)	54.25	Advertising expenses (0.999) Change in stock for finished goods (0.989) Change in stock for wipWIP and semi finished goods(0.999) WIP cycle(days)(0.98) WIP turnover(times)(.099)	89.98

In the automobile sector, there is the only single factor that explains the variability in case of absence of bullwhip effect is having a variable like current ratio (times), WIP turnover (times) and Return on capital employed whereas the variables in presence of bullwhip effect change completely. Advertisement expenses, raw material cycle (days), raw material turnover (times) are the variables in major component. Thus, advertisement plays an important role in the bullwhip effect in the automobile sector. In the energy sector, non-experiencing bullwhip effect companies, sales promotion expenses are found in major component with the change in stock for WIP goods and WIP cycle. In companies that are experiencing the bullwhip effect advertisement expenses, finished goods cycle (days), raw material turnover (times), and return on capital employed founds in major components of the energy sector. So, in the energy sector, direct sales promotion together with the work-in-progress cycle is the major component in the absence of bullwhip effect. In the FMCG sector, the situation is reversed as far as promotion strategies is concerned. Non-direct advertisement is found in the component that belongs to the absence of bullwhip effect whereas sales promotion is in the component that belongs to the presence of bullwhip effect. In IT sector the loading of sales promotion in case of presence of bullwhip effect is more than in the case where no bullwhip effect exists but rather than promotional effect it is the replenishment like work-in-progress and finished good cycle that exists in major component of stable sectors. In the FMCG sector, finished goods turnover is in the component having no bullwhip effect whereas work in progress cycle and turnover is in the components for companies that are facing disruption. Similar, interpretation can be made using Table 5.

Conclusion and Future Scope

Bullwhip effect causes hindrance in supply chain management due to which the operations under the supply chain are not able to optimise. The bullwhip effect is experienced in nearly all types of sectors. The plethora

of research is available on identifying the causing and mitigating of the bullwhip effect. Most of these methods are based on simulations, and some of the case studies on primary data are also available. There is a dearth of research on secondary observations to identify the factors causing the bullwhip effect. The present study is carried out on 10 different Indian sectors, and factor analysis has been performed on 19 identified operational and financial variables. The study is novel itself because it is exploring bullwhip effect considering it as an operational challenge rather than the behavioural issue. It has been found that the factors affecting the bullwhip effect are varying with the sector to sector. The major component in factor analysis has been studied because it explains more variability than other components. Advertisement, sales promotion and rebate & discount do play a role in causing the bullwhip effect. Size, WIP inventory and profit also play a major role in causing of the bullwhip effect. It also has been found that the WIP cycle, finished the good cycle and raw material turnover are having an impact on bullwhip effect. The present research focuses on the fact that the nature of the sector also affecting the bullwhip effect as the bullwhip effect varies from sector to sector. Present research also identified the operational and financial variables to deal with the bullwhip effect. Frequency of the variable to seek their importance in causing of bullwhip effect is also computed. The factor analysis is also performed to see how the factors are different for the companies that are experiencing bullwhip effect from that which are not experiencing the same. It has been found that the variables in major component factors vary from sector to sector and in some cases where variable are same their factor loading component varies. The future scope of the research lies in two ways, every component of factor can be studied to see how these vary from sector to sector and secondly path analysis of these factors can be performed to identify the cause of bullwhip effect. The magnitude by which these factors are affecting the bullwhip effect (in its absence or existence) is the area of future research.

References

Akyuz, G. A., & Erkan, T. E. (2010). Supply chain performance measurement: A literature review. *International Journal of Production Research, 48*(17), 5137-5155.

Burbidge, J. L. (1991). *Period batch control (PBC) with GT - The way forward from MRP.* Paper presented at the BPCIS Annual Conference, Birmingham.

Cachon, G. P., Randall, T., & Schmidt, G. M. (2007). In search of the bullwhip effect. *Manufacturing and Service Operations Management, 9*, 457-479.

Cagnazzo, L., Taticchi, P., & Brun, A. (2010). The role of performance measurement systems to support quality improvement initiatives at supply chain level. *International Journal of Productivity and Performance Management, 59*(2), 163-185.

Cannella, S., Povoa, A. B., Framinan, J., & Relvas, S. (2013). Metrics for bullwhip effect analysis. *Journal of the Operational Research Society, 64*, 1-16.

Chang, T.-H., Fu, H.-P., Lee, W.-I., Lin, Y., & Hsueh, H.-C. (2007). A study of an augmented CPFR model for the 3C retail industry. *Supply Chain Management: An International Journal, 12*, 200-209.

Chen, F., Drezner, Z., Ryan, J. K., & Simchi-Levi, D. (2000). Quantifying the bullwhip effect in a simple supply chain: The impact of forecasting, lead times, and information. *Management Science, 46*(3), 436-443.

Chen, I. J., & Paulraj, A. (2004). Understanding supply chain management: Critical research and a theoretical framework. *International Journal of Production Research*, *42*(1), 131-163.

Chiang, C.-Y., Lin, W. T., & Nallan, S. C. (2016). An empirically-simulated investigation of the impact of demand forecasting on the bullwhip effect: Evidence from U.S. auto-industry. *International Journal of Production Economics, 177*, 53-65.

Christopher, M. (1994). *Logistics and supply chain management.* London, UK: Pitman Publishing.

Christopher, M. G. (1992). *Logistics and supply chain management.* Pitman Publishing, London, UK.

Disney, S. M., Farasyn, I., Lambrecht, M. R., Towill, D. R., & Velde, W. V. D. (2007). Controlling bullwhip and inventory variability with the golden smoothing rule. *European Journal of Industrial Engineering*, *1,* 241-265.

Disney, S. M., & Towill, D. R. (2003). The effect of vendor managed inventory (VMI) dynamics on the bullwhip effect in supply chains. *International Journal of Production Economics, 85*, 199-215.

Dominguez, R., Cannella, S. S., & Framinan, J. M. (2015). The impact of the supply chain structure on bullwhip effect. *Applied Mathematical Modelling, 39*(23), 7309-7325.

Duc, T. T., Luong, H. T., & Kim, Y.-D. (2008). A measure of bullwhip effect in supply chains with a mixed autoregressive-moving average demand process. *European Journal of Operational Research, 187*, 243-256.

Fisher, M. L. (1997). What is the right supply chain for your product?. *Harvard Business Review* (March-April), 105-116.

Forrester, J. W. (1961). Industrial dynamics - A major breakthrough for decision makers. *Harvard Business Review, 4*, 37-66.

Fransoo, J. C., & Wouters, M. J. (2000). Measuring the bullwhip effect in supply chain. *Supply Chain Management: An International Journal, 5*(2), 78-89.

Geary, S., Disney, S. M., & Towill, D. R. (2006). On bullwhip in supply chains-historical review, present practice and expected future impact. *International Journal of Production Economics, 101*, 2-18.

Green, K. W., McGaughey, R., & Casey, K. M. (2006). Does supply chain management strategy mediate the association between market orientation and organizational performance?. *Supply Chain Management: An International Journal*, *11*(5), 407-414.

Hamister, J. W., & Suresh, N. C. (2008). The impact of pricing policy on sales variability in a supermarket retail context. *International Journal of Production Economics, 111*, 441-455.

Houlihan, J. B. (1987). International supply chain management. *International Journal of Physical Distribution & Logistics Management, 17,* 51-66.

Hull, B. (2005). The role of elasticity in supply chain performance. *International Journal of Production Economics, 98*, 301-314.

Isaksson, O. H., & Seifert, R. W. (2016). Quantifying the bullwhip effect using two-echelon data: Across-industry empirical investigation. *International Journal of Production Economics, 171*, 311-320.

Jones, M. R., & Towill, D. R. (1997). Information enrichment: Designing the supply chain for competitive advantage. *Supply Chain Management*, *2*(4), 137-149.

Jin, M., DeHoratius, N., & Schmidt, G. (2017). Want to reduce the bullwhip? Measure it. Here's how. *Supply Chain Management: An International Journal, 22*, 297-304.

Kaipia, R., Korhonen, H., & Hartiala, H. (2006). Planning nervousness in a demand supply network: An empirical study. *The International Journal of Logistics Management, 17*, 95-113.

Kelepouris, T., Miliotis, P., & Pramatari, K. (2008). The impact of replenishment parameters and information sharing on the bullwhip effect: A computational study. *Computers & Operations Research, 35*, 3657-3670.

Lamming, R., & Hampson, J. (1996). The environment as a supply chain management issue. *British Journal of Management*, *7*(Special Issue), 45-62.

Lee, H. L., & Billington, C. (1992). Managing supply chain inventory: Pitfalls and opportunities. *Sloan Management Review*, *33*(3), 65-73.

Lee, H. L., Padmanabhan, V., & Whang, S. (1997). Information distortion in a supply chain: The bullwhip effect. *Management Science, 43*(4), 546-558.

Li, C. (2013). Controlling the bullwhip effect in a supply chain system with constrained information flows. *Applied Mathematical Modelling, 37*, 1897-1909.

Lummus, R. R., Duclos, L. K., & Vokurka, R. J. (2003). The impact of marketing initiatives on the supply chain. *Supply Chain Management: An International Journal, 8*(4), 317-323.

Macbeth, D. K., Ferguson, N., & Neil, G. (1992). *Developing customer-supplier relationships.* First PSERG Conference, Glasgow.

Mackelprang, A. W., & Malhotra, M. K. (2015). The impact of bullwhip on supply chains: Performance pathways, control mechanisms, and managerial levers. *Journal of Operations Management, 36*, 15-32.

Mahmoudi, J., & Lamothe, J. (2006). Risk analysis for corporation policies benefits in reducing the bullwhip effect. *IFAC Proceedings Volumes, 39*(3), 585-590.

Mela, C. F., Jedidi, K., & Bowma, D. (1998). The long term impact of promotions on consumer stockpiling behaviour. *Journal of Marketing Research, 35*(2), 250-262.

Metters, R. (1997). Quantifying the bullwhip effect in supply chains. *Journal of Operations Management*, *15*(2), 89-100.

Neslin, S. A. (1990). A market response model for coupon promotions. *Marketing Science, 9*(2), 125-145.

New, S. J., & Payne, P. (1995). Research frameworks in logistics: Three models, seven dinners and a survey. *International Journal of Physical Distribution and Logistics Management*, *25*(10), 60-77.

Paik, S.-K., & Bagchi, P. K. (2007). Understanding the causes of the bullwhip effect in supply chain. *International Journal of Retail & Distribution Management, 35*, 308-324.

Ravichandran, N. (2006). Managing bullwhip effect: Two case studies. Indian Institute of Management, Ahmedabad, W.P. No 2006-08-01, 1-20.

Seles, B. M., Jabbour, A. B., Jabbour, C. J., & Dangelico, R. M. (2016). The green bullwhip effect, the diffusion of green supply chain practices, and institutional pressures: Evidence from the automotive sector. *International Journal of Production Economics, 182*, 342-355.

Sterman, J. (1989). Modeling managerial behavior: Misperceptions of feedback in a dynamic decision making. *Management Science, 35*, 321-339.

Tangsucheeva, R., & Prabhu, V. (2013). Modeling and analysis of cash-flow bullwhip in supply chain. *International Journal of Production Economics, 145*(1), 431-447.

Tsai, C. Y. (2008). On supply chain cash flow risks. *Decision Support System, 44,* 1031-1042.

Vickery, S. K., Jayaram, J., Droge, C., & Calantone, R. (2003). The effects of an integrative supply chain strategy on customer service and financial performance: An analysis of direct versus indirect relationships. *Journal of Operations Management, 21*, 523-539.

West, K. D. (1986). A variance bounds test of the linear quadratic inventory model. *Journal of Political Economy, 94*(2), 374-401.